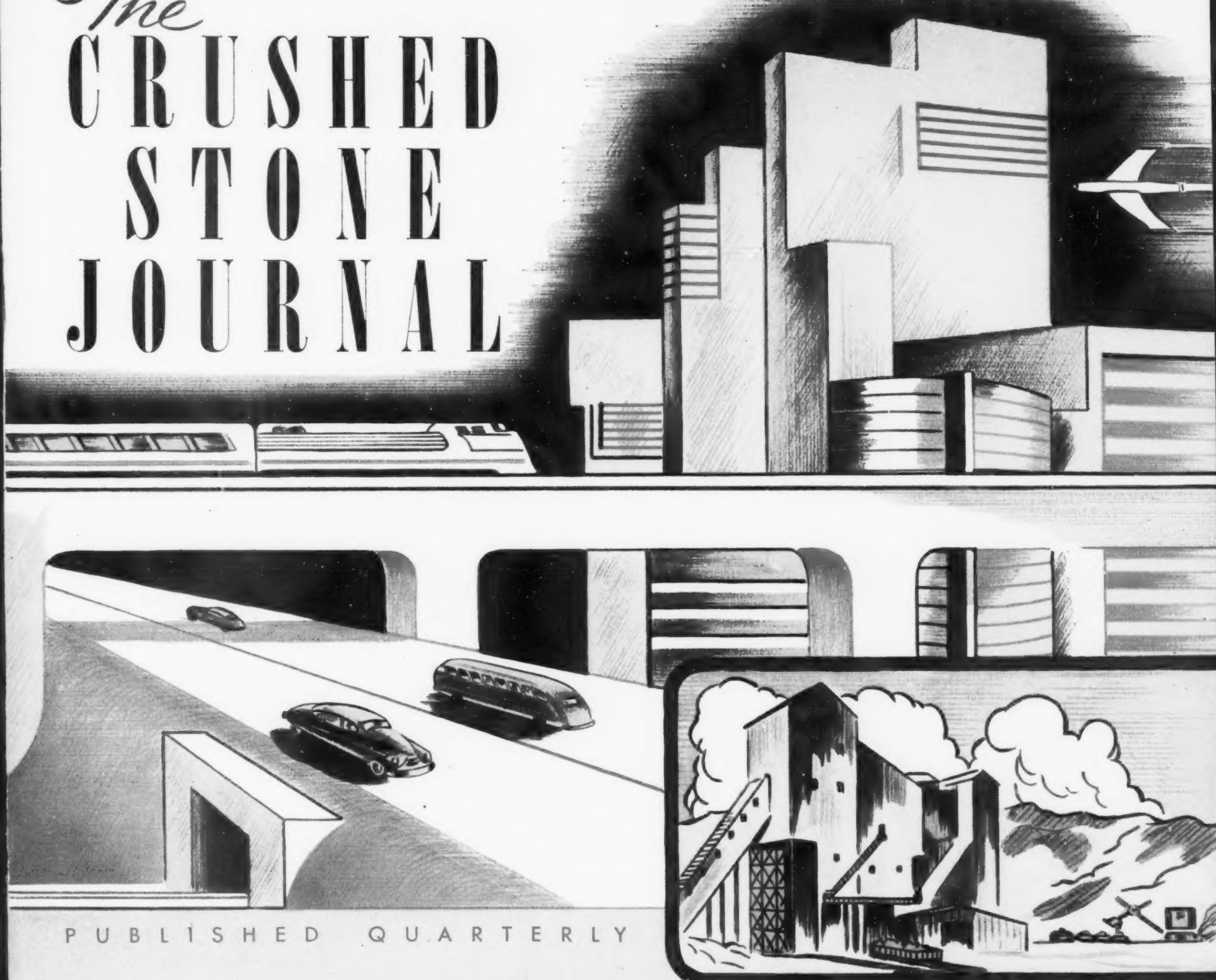
The CRUSHED STONE JOURNAL



PUBLISHED QUARTERLY

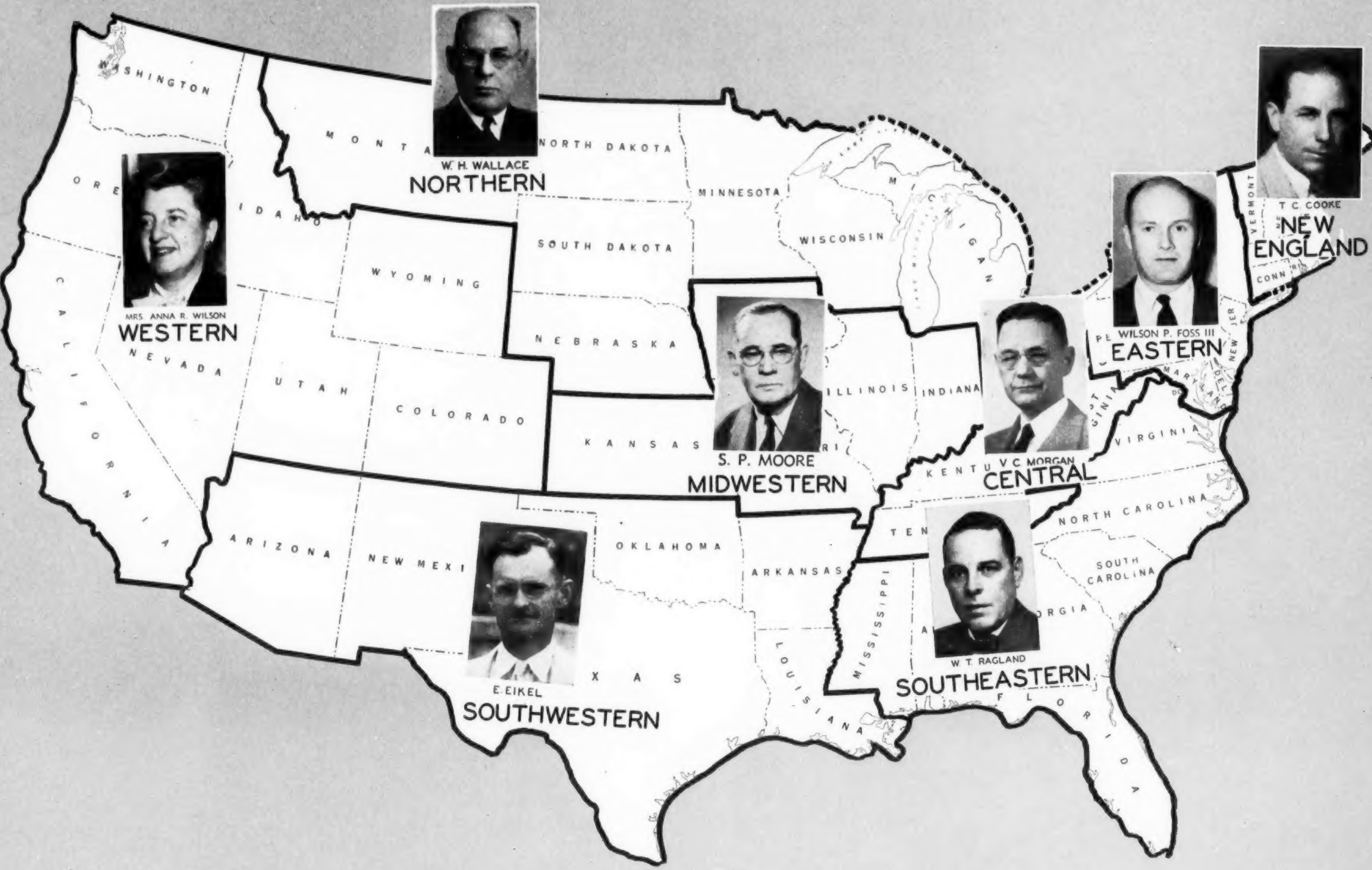
In This Issue

March 1950

OFFICIAL PUBLICATION · NATIONAL CRUSHED STONE ASSOCIATION

MAP SHOWING REGIONS AND REGIONAL VICE PRESIDENTS FOR 1950

NATIONAL CRUSHED STONE ASSOCIATION



The Crushed Stone Journal

Official Publication of the NATIONAL CRUSHED STONE ASSOCIATION

J. R. BOYD, Editor

Contents

J. REID CALLANAN

President
Callanan Road Improvement Co.
South Bethlehem, N. Y.

●

Elected President

NATIONAL CRUSHED STONE ASSOCIATION

at its 33rd Annual Convention

Chicago, Illinois

January 30-February 1, 1950

P. E. HEIM

Vice President
Carbon Limestone Co.
Lowellville, Ohio

●

Elected President

AGRICULTURAL LIMESTONE INSTITUTE

at its 5th Annual Convention

Chicago, Illinois

February 1-3, 1950

THE CRUSHED STONE JOURNAL

WASHINGTON, D. C.

Vol. XXV No. I PUBLISHED QUARTERLY MARCH 1950

Chicago Conventions Set New Record Exposition Occupies Over 10,000 Sq. Ft.

SUBSTANTIALLY exceeding even the most optimistic estimates, consolidated registration figures for the 33rd Annual Convention of NCSA and the 5th Annual Convention of ALI, held at The Stevens, Chicago, during the week of January 29, added to the amazing total of 1265. This figure surpasses by over 300 the previous high of 920, established when both groups met at the Netherland Plaza, Cincinnati, in January of 1948.

The program proved to be of outstanding interest, as evidenced by the exceptionally large attendance at each of the convention sessions.

The panel discussion on operating problems soon developed to the point of "standing room" only and the session for salesmen attracted substantially more than had been anticipated. Many of the talks will be made available either through the columns of the Journal directly, in mimeographed form, or printed separately.

The Manufacturers Division Exposition, participated in by 69 exhibitors occupying over 10,000 sq. ft. of exhibit space, displayed a wider variety of equipment than ever before in the history of the exposition, and much of this equipment could be seen in actual operation.

In the following, attention is directed to events of the convention believed to be of particular interest to members of the National Crushed Stone Association.

Officers and Board of Directors Elected

The annual business meeting of the Association was held on Tuesday morning, January 31.

Introductory to the report of the Nominating Committee, its Chairman, N. E. Kelb, called attention to the fact that the function of the Committee was to place before the membership candidates for the Board and for the various offices, who, in the judgment of the Committee, seemed qualified to serve. Chairman Kelb called particular attention to the fact that nominations from the floor were entirely in order and that no one should hesitate to place in nomination the name of anyone who he felt might be better qualified than those suggested by the Committee. It was then pointed out that the By-Laws of the Association provide that there shall be a Board of Directors consisting of 48 members; that the President, eight Regional Vice Presidents, the Chairman and two representatives of the Manufacturers Division, and the President and two representatives of

Meeting of Newly Elected NCSA Board of Directors
The Stevens, Chicago, Illinois, January 31, 1950

J. REID CALLANAN
Callanan Road Improvement Co.
South Bethlehem, N. Y.
President
National Crushed Stone Association

P. E. HEIM
Carbon Limestone Co.
Lowellville, Ohio
President
Agricultural Limestone Institute

J. CRAIG McLANAHAN
McLanahan & Stone Corp.
Hollidaysburg, Pa.
Chairman
Manufacturers Division

EXECUTIVE COMMITTEE

of the

NATIONAL CRUSHED STONE ASSOCIATION

for the year 1950

G. A. AUSTIN
Consolidated Quarries Corp.
Decatur, Ga.

WILSON P. FOSS, III
New York Trap Rock Corp.
New York, N. Y.

OTHO M. GRAVES
General Crushed Stone Co., Easton, Pa.

S. P. MOORE
Concrete Materials and Construction Co.
Cedar Rapids, Iowa

RUSSELL RAREY
Marble Cliff Quarries Co., Columbus, Ohio

W. F. WISE
Southwest Stone Co.
Dallas, Texas

W. S. WESTON, JR.
Weston & Brooker Co.
Columbia, S. C.

the Agricultural Limestone Institute shall be ex officio members of the Board, leaving not more than 33 additional Directors to be elected by the membership.

Regional Vice Presidents

In accord with the recommendations of the Nominating Committee, the following were unanimously elected as Regional Vice Presidents for the regions indicated:

Eastern—Wilson P. Foss, III, New York Trap Rock Corp., New York, N. Y.

New England—T. C. Cooke, Lynn Sand and Stone Co., Swampscott, Mass.

Midwestern—S. P. Moore, Concrete Materials and Construction Co., Cedar Rapids, Iowa

Southeastern—W. T. Ragland, Superior Stone Co., Raleigh, N. C.

Central—V. C. Morgan, Kentucky Stone Co., Louisville, Ky.

Northern—W. H. Wallace, Wallace Stone Co., Bay Port, Mich.

Southwestern—E. Eikel, Servtex Materials Co., New Braunfels, Texas.

Western—Mrs. Anna R. Wilson, Granite Rock Co., Watsonville, Calif.

Election of Directors

The following were then unanimously elected directly to the Board of Directors in accord with recommendations made by the Nominating Committee:

Newly Elected to NCSA Board

MARGARET McD. SMITH
Central Rock Co.
Lexington, Ky.

G. A. Austin, Consolidated Quarries Corp., Decatur, Ga.
L. J. Boxley, Blue Ridge Stone Corp., Roanoke, Va.
H. H. Brandon, Melvin Stone Co., Melvin, Ohio
Bruce S. Campbell, Harry T. Campbell Sons' Corp., Towson, Md.
W. N. Carter, National Stone Co., Joliet, Ill.
A. J. Cayia, Inland Lime and Stone Co., Manistique, Mich.
Arthur F. Eggleston, John S. Lane & Son, Inc., Meriden, Conn.
Otho M. Graves, General Crushed Stone Co., Easton, Pa.
G. F. Hammerschmidt, Elmhurst-Chicago Stone Co., Elmhurst, Ill.
R. G. L. Harstone, Canada Crushed Stone Ltd., Hamilton, Ontario, Can.
C. P. Haun, Franklin Limestone Co., Nashville, Tenn.
J. L. Heimlich, LeRoy Lime and Crushed Stone Corp., LeRoy, N. Y.
R. P. Immel, American Limestone Co., Knoxville, Tenn.
N. E. Kelb, Cumberland Quarries, Inc., Indianapolis, Ind.
R. T. Lassiter, Southern Aggregates Corp., Raleigh, N. C.
J. C. Lauber, Minneapolis, Minn.
G. D. Lott, Jr., Palmetto Quarries Co., Columbia, S. C.
M. E. McLean, East St. Louis Stone Co., East St. Louis, Ill.
A. W. McThenia, Acme Limestone Co., Fort Spring, W. Va.
Paul M. Nauman, Dubuque Stone Products Co., Dubuque, Iowa
John H. Odenbach, Dolomite Products Co., Rochester, N. Y.
H. E. Rainer, Federal Crushed Stone Corp., Buffalo, N. Y.
Russell Rarey, Marble Cliff Quarries Co., Columbus, Ohio
W. R. Sanborn, Lehigh Stone Co., Kankakee, Ill.
James Savage, Buffalo Crushed Stone Corp., Buffalo, N. Y.
A. T. Smith, Rock Hill Quarries Co., St. Louis, Mo.
Margaret McD. Smith, Central Rock Co., Lexington, Ky.
O. M. Stull, Liberty Limestone Corp., Buchanan, Va.
F. B. Thacher, Carbon Limestone Co., Lowellville, Ohio
W. S. Weston, Jr., Weston and Brooker Co., Columbia, S. C.
D. L. Williams, Virginian Limestone Corp., Ripplemead, Va.
W. F. Wise, Southwest Stone Co., Dallas, Texas
A. L. Worthen, New Haven Trap Rock Co., New Haven, Conn.

J. Reid Callanan Elected President

As the concluding responsibility of the Nominating Committee, Chairman Kelb announced its recommendation for President as follows: "Your Committee gave a great deal of thought and consideration as to who should head up the Association for the coming year. We feel that we have selected a man who is respected for his intelligence, good judgment, and his ability to handle himself under trying situations; one who is gracious and of whom we will all be proud. It is my pleasure now to present to the convention as the nominee of your Committee for the presidency: J. Reid Callanan of The Callanan Road Improvement Company, South Bethlehem, New York."

As there were no further nominations made from the floor, J. Reid Callanan was declared unanimously elected President and was escorted to the platform by Ex-Presidents G. A. Austin and Russell Rarey, while the audience arose and applauded.

In accepting the high office accorded him, President-Elect Callanan spoke as follows:

"Fellow members of the National Crushed Stone Association and guests: I thought that I knew what it was to be nervous on the somewhat rare occasions when I am called upon to play the piano in public. I now realize that I did not know what it was to be really nervous until this morning.

"I was thinking last night just what I might say to you this morning in acknowledgment of this wonderful tribute. (You see, I shared the confidence of the Nominating Committee in trying to keep my nomination a secret.) I was afraid that I would do one of two things if I was not careful: I would either talk too long and appear a little stupid in doing so, or say too little and thereby inadequately express the thoughts which your kindness has brought so close to me. It often seems so difficult to say just enough and no more.

"So, I wrote down what I felt that I would want most to say to you but when I had finished I realized

that what I had written down seemed a little bit stilted, perhaps a bit pompous and not, after all my trouble, really what I wanted to say at all. But then, I thought, 'after all, I am going to be speaking to good friends, so why don't I speak to them collectively as I would to each of them privately and simply thank them from the bottom of my heart for being so very nice and considerate to me.' And that is what I am trying to do now.

"I shall remember this as one of the happiest days of my life. I find it difficult, as I know you will appreciate, for me to adequately express to you folks my gratitude and appreciation. I hope I shall prove worthy of the confidence you have expressed in making me your President. Too, I want to pledge you my loyalty to the best interest of our National Crushed Stone Association. I shall do everything I can to help carry on the fine tradition established by all who have preceded me. We owe much, ladies and gentlemen, to the unselfish and unstinting efforts of the men who, in the earlier days of our Association did so much to shape its affairs and guide its destinies, not infrequently through very trying times. Some of these men have now passed on, many others are still vigorously active in the affairs of the Association. I think it would be most appropriate, ladies and gentlemen, if we here and now express our appreciation by applauding these gentlemen for their great service to us. Won't you join me?

"I hope that my business associates will agree that I should spend some of the time during the next twelve months in visiting our members in various parts of the country. Business affairs, of course, will prevent my doing this as much as I would like but I do hope to get around the country as much as I can find time to do so. I want to visit particularly some of our members whom I don't have the privilege of knowing, or of knowing well. I hope to be able to expand my field of acquaintance of Association members within the next year.

"In closing I want to say to you that some of the best friends I have are among you. I would like to ask each and every one of you, in starting off our new year in the Association, to share with me the happiness I feel at this moment. We can, together, I know, enjoy a most pleasurable year in successfully carrying on the affairs of our Association.

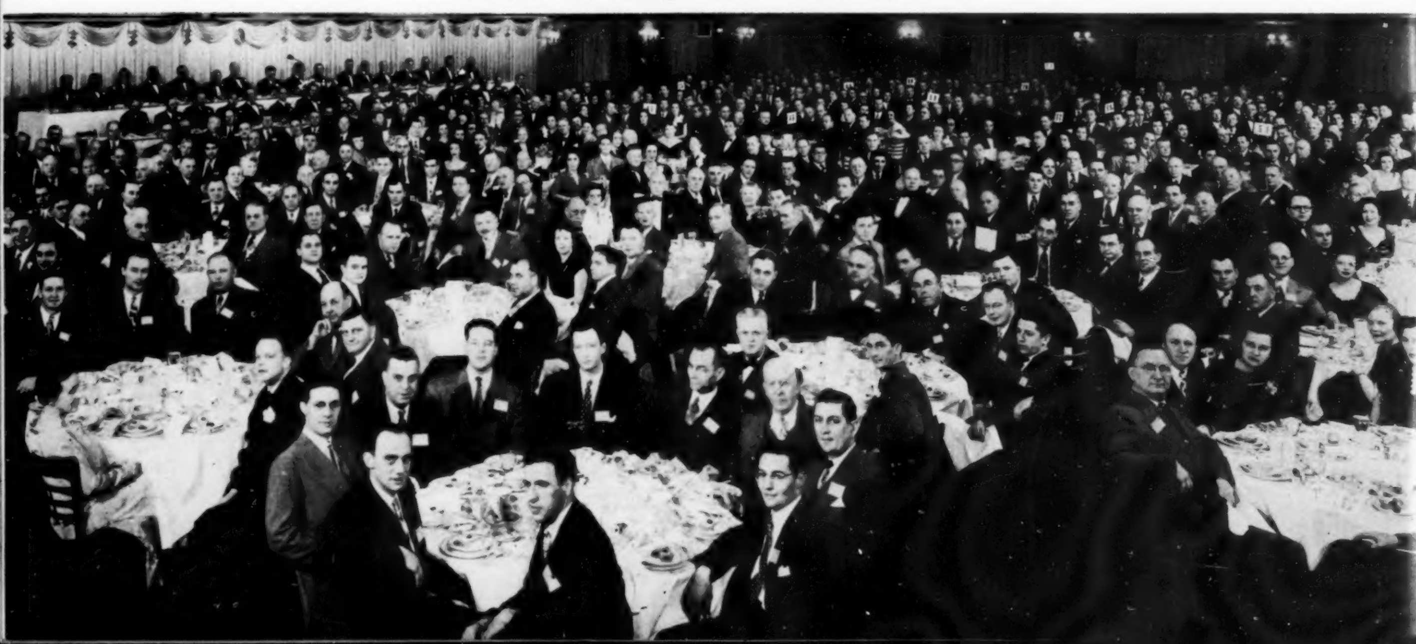
"Thank you!"

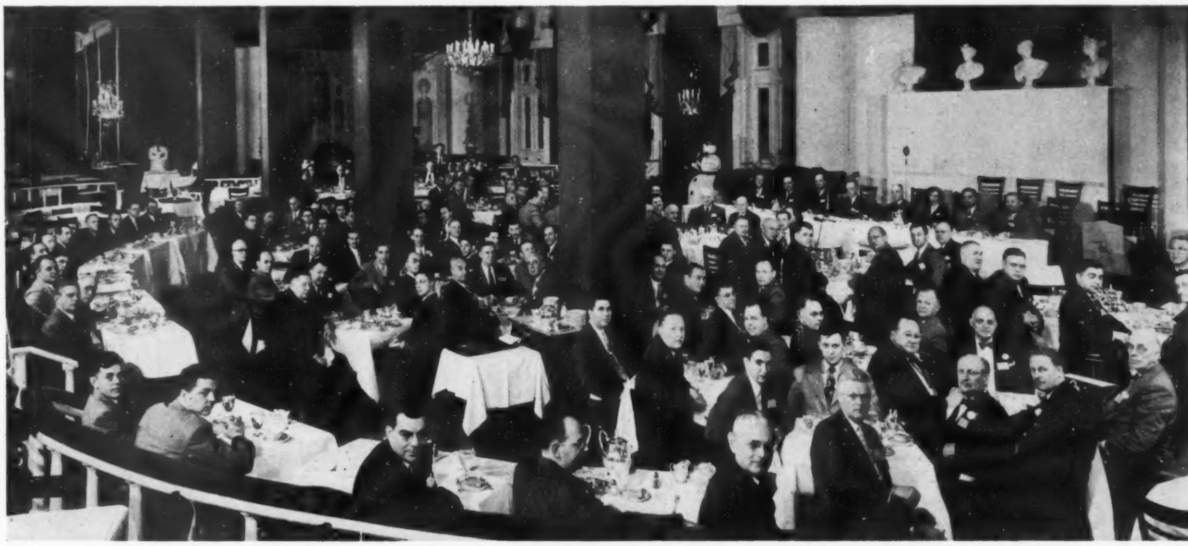
Appreciation to Retiring President W. S. Weston, Jr.

At the conclusion of President-Elect Callanan's words of acceptance, Otho M. Graves spoke as follows:

"Gentlemen, I have asked permission to say something which I think should be said and which I am very happy to say on behalf of all of us. There is only one thing that saddens us in the election of a new man, even Reid Callanan, to the presidency, and that is that it causes us to lose Steve Weston. Steve has been an able President of this Association. We are all aware of his unusual qualifications and

Joint Banquet National Crushed Stone Association and Agricultural Limestone Institute
The Stevens, Chicago, Illinois, February 1, 1950





Manufacturers Division Annual Business Meeting Luncheon
The Stevens, Chicago, Illinois, January 31, 1950

recognize the earnestness and energy with which he has conducted his administration. His intelligent supervision of our affairs has been marked, his courtesy and patience have never failed and we have all enjoyed the charm of his personality. We will all miss him, but Steve, I want to say to you on behalf of all of the ex-presidents that we welcome you to our ranks!"

Representatives of ALI and Manufacturers Division on NCSA Board

At the annual business meeting of the Manufacturers Division, held at luncheon on Tuesday, January 31, J. Craig McLanahan was elected Chairman of the Division and Irwin F. Deister and Cottrell Farrell were designated to serve with him on the NCSA Board of Directors.

At the annual business meeting of the Agricultural Limestone Institute, held on Friday, February 3, P. E. Heim was elected President of the Institute and H. A. Clark and H. C. Krause were designated to serve with him on the NCSA Board of Directors.

New Board Elects Executive Committee and Staff Officers

At the meeting of the newly elected Board of Directors, held Tuesday afternoon, January 31, the following were elected to the positions as indicated:

Executive Committee

Elected Members

G. A. Austin, Consolidated Quarries Corp., Decatur, Ga.
Wilson P. Foss, III, New York Trap Rock Corp., New York, N. Y.
Otho M. Graves, General Crushed Stone Co., Easton, Pa.
S. P. Moore, Concrete Materials and Construction Co., Cedar Rapids, Iowa
Russell Rarey, Marble Cliff Quarries Co., Columbus, Ohio
W. S. Weston, Jr., Weston and Brooker Co., Columbia, S. C.
W. F. Wise, Southwest Stone Co., Dallas, Texas

Ex Officio Members

J. Reid Callanan, President, National Crushed Stone Association
P. E. Heim, President, Agricultural Limestone Institute
J. Craig McLanahan, Chairman, Manufacturers Division

JAMES SAVAGE
Buffalo Crushed Stone Corp., Buffalo, N. Y.
Re-elected Treasurer

Officers

Treasurer—James Savage
Administrative Director and Secretary—J. R. Boyd
Engineering Director—A. T. Goldbeck
Field Engineer—J. E. Gray
Assistant Secretary—Beatrice G. Gay

Beatrice G. Gay Elected Assistant Secretary

It is a real pleasure to report that at the meeting of the newly elected Board of Directors of NCSA,

J. Craig McLanahan
McLanahan & Stone Corp.
Chairman
Manufacturers Division

EXECUTIVE COMMITTEE

of the

MANUFACTURERS DIVISION

National Crushed Stone Association
for the year 1950

Irwin F. Deister
Deister Machine Co.
Fort Wayne, Ind.

R. C. Johnson
Simplicity Engineering Co.
Durand, Mich.

Cottrell Farrell
Easton Car and Construction Co.
Easton, Pa.

B. R. Maloney
E. I. du Pont
de Nemours & Co.
New York, N. Y.

J. Reid Callanan
President, NCSA
Callanan Road Improvement Co.
South Bethlehem, N. Y.

NEWLY ELECTED MEMBERS OF MANUFACTURERS DIVISION BOARD

W. E. COLLINS, JR.
Atlas Powder Co.
Wilmington, Del.

G. C. HOLTON
American
Cyanamid Co.
New York, N. Y.

P. H. HUNTER
Harnischfeger
Corp.
Milwaukee, Wis.

G. H. KEPPEL
C. G. Buchanan
Crushing Machinery
Division, Birdsboro Steel
Foundry and Machine Co.
Birdsboro, Pa.

on Tuesday, January 31, 1950, Beatrice G. Gay was elected Assistant Secretary.

For her loyal and faithful service to the Association, extending over a period in excess of ten years, this recognition is a well deserved tribute.

J. Craig McLanahan Elected Chairman of Manufacturers Division

The annual business meeting of the Manufacturers Division of NCSA was held at luncheon on Tuesday, January 31, 1950, with approximately 160 in attendance.

J. Craig McLanahan, General Manager of McLanahan and Stone Corporation, Hollidaysburg, Pennsylvania, was elected Chairman of the Division to succeed Cottrell Farrell, who had held the office for the last two years.

In addition, the following were elected as indicated:

Vice Chairmen

Irwin F. Deister, Deister Machine Co., Fort Wayne, Ind.
R. C. Johnson, Simplicity Engineering Co., Durand, Mich.
B. R. Maloney, E. I. du Pont de Nemours and Co., New York, N. Y.

Elected Directors

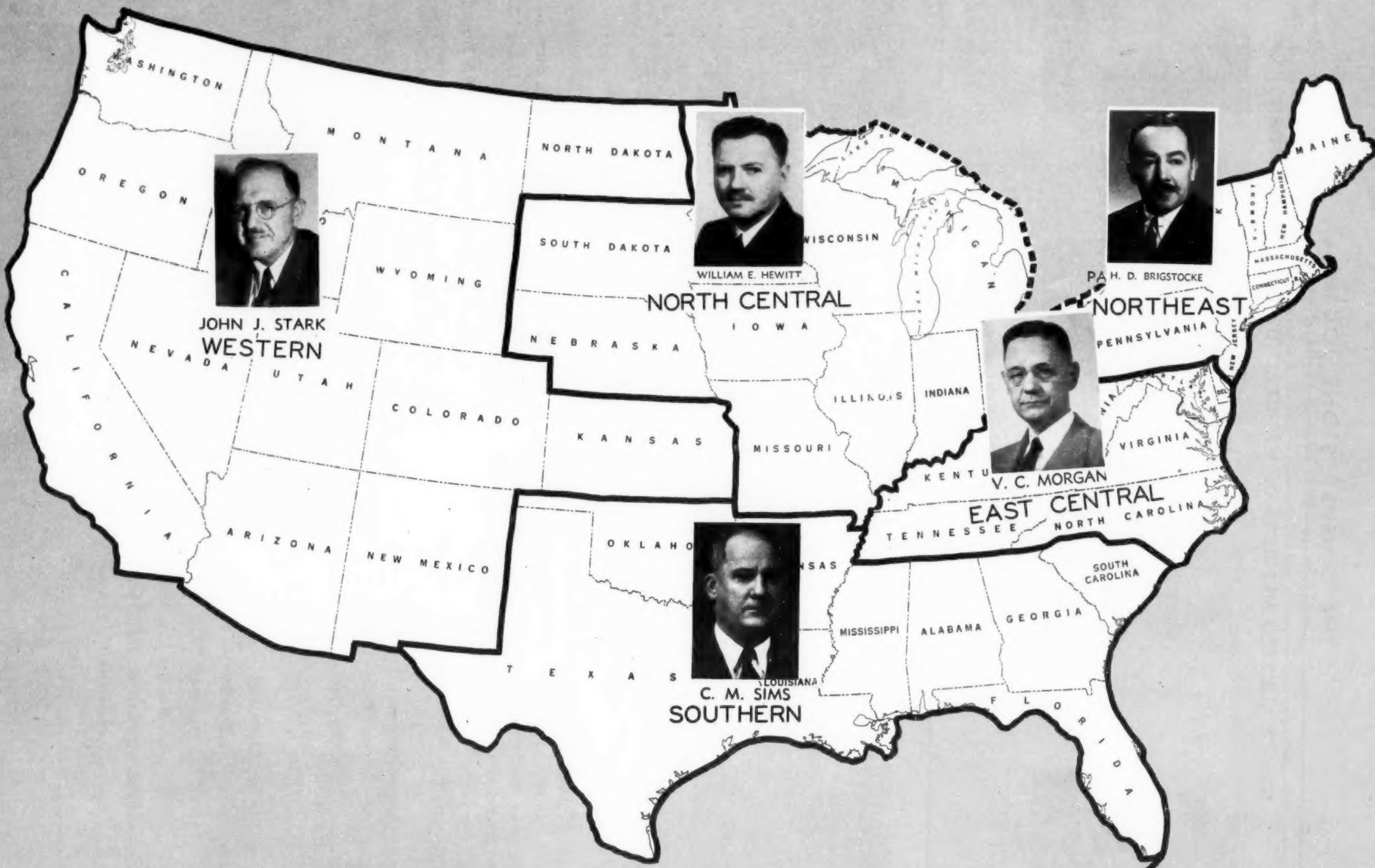
E. C. Anderson, Kensington Steel Co., Chicago, Ill.
D. McM. Blackburn, Hendrick Mfg. Co., Carbondale, Pa.
W. E. Collins, Jr., Atlas Powder Co., Wilmington, Del.
A. E. Conover, Hewitt-Robins, Inc., New York, N. Y.
L. A. Eiben, Northern Blower Co., Cleveland, Ohio
S. S. Ellsworth, Ensign Bickford Co., Simsbury, Conn.
R. F. Feind, Allis-Chalmers Mfg. Co., Milwaukee, Wis.
C. O. Friend, Nordberg Mfg. Co., Milwaukee, Wis.
E. J. Goes, Koehring Co., Milwaukee, Wis.
E. M. Heuston, Bucyrus-Erie Co., South Milwaukee, Wis.
G. C. Holton, American Cyanamid Co., New York, N. Y.
P. H. Hunter, Harnischfeger Corp., Milwaukee, Wis.
G. H. Keppel, C. G. Buchanan Crushing Machinery Division, Birdsboro Steel Foundry and Machine Co., Birdsboro, Pa.
R. D. Ketner, General Electric Co., Schenectady, N. Y.
W. W. King, W. S. Tyler Co., Cleveland, Ohio
Kenneth Lindsay, Iowa Mfg. Co., Cedar Rapids, Iowa
M. L. McCormack, Ingersoll-Rand Co., New York, N. Y.
L. C. Mosley, Marion Power Shovel Co., Marion, Ohio
R. M. Murdock, Frog, Switch & Mfg. Co., New York, N. Y.
Milo A. Nice, Hercules Powder Co., Wilmington, Del.
F. O. Reedy, Kennedy-Van Saun Mfg. & Eng. Corp., New York, N. Y.
W. A. Rundquist, Pioneer Engineering Works, Inc., Minneapolis, Minn.
J. B. Terbell, American Manganese Steel Division, American Brake Shoe Co., New York, N. Y.
J. A. Trainor, Taylor-Wharton Iron and Steel Co., High Bridge, N. J.
F. B. Ungar, Ludlow-Saylor Wire Co., St. Louis, Mo.

Elected Representatives on NCSA Board

Irwin F. Deister, Deister Machine Co., Fort Wayne, Ind.
Cottrell Farrell, Easton Car and Construction Co., Easton, Pa.

New Board, Manufacturers Division

MAP SHOWING REGIONS AND REGIONAL VICE PRESIDENTS FOR 1950 AGRICULTURAL LIMESTONE INSTITUTE



5th ALI Convention The Best Yet

THE 5th Annual Convention of the Agricultural Limestone Institute, held at The Stevens in Chicago on February 1, 2, and 3, 1950, is now history, but it will be long remembered by those who attended and participated in the sessions. The general sessions were well attended, the speakers were informative, and the lighter side of the convention was accentuated by a grand reception and banquet, a cocktail party and buffet dinner, and two luncheons. All past attendance records were broken. The total number of persons registered for the week was 1265.

Joint Sessions on Plant Operation and Selling

The entire day of Wednesday, February 1, was devoted to joint sessions of the Agricultural Limestone Institute and the National Crushed Stone Association. The morning of that day was spent on a panel discussion of operating problems, always a well-attended feature of the convention. G. D. Lott, Jr., of Palmetto Quarries Company, Columbia, South Carolina, and Marvin Nelson, of Concrete Materials and Construction Company, Cedar Rapids, Iowa, presided as co-chairmen and were ably assisted by a panel of four production experts.

Those who are sales-minded had the opportunity on Wednesday afternoon of refreshing themselves in the art of salesmanship. O. J. McClure, of Chicago, spoke on "Salesmanship—A Lost Art" in a most convincing manner. This was followed by questions from the floor which developed additional points of value.

Geology and Conservation

The program on Thursday was of particular interest to agricultural limestone producers. First was the excellently presented talk by J. E. Lamar on "The Geology of Limestones," which was followed by a luncheon address by Maurice H. Lockwood on "Teamwork," in which the mutuality of interest between the limestone and fertilizer industries was explained.

In the afternoon two excellent talks on conservation were given. Alvin V. McCormack, Director of the Agricultural Conservation Programs Branch, PMA, spoke on the problems of his agency in a talk entitled "Between the Rocks." He was followed by R. H. Musser, Regional Conservator of the Soil Conservation Service, who reported on the conservation job being done by his organization and the enormous task which lies ahead. Both speakers stressed the important part played by limestone in soil conservation.

Agronomists Give Helpful Information

Two of the Nation's outstanding agronomists talked on the more technical aspects of soil liming. F. V. Burcalow, of The University of Wisconsin, spoke convincingly on grassland farming and its growing importance in American agriculture. George H. Enfield, of Purdue University, ably presented the results obtained in Indiana from years of study and comprehensive research work conducted on the several experimental farms in that state. In both cases the fundamental need for lime was emphasized.

Symposium on Promotion

One of the high lights of the convention program was the symposium on Thursday afternoon, in which an officer or staff member of six state associations gave short, concise reports on their promotional activities. This was a most interesting session and many valuable ideas were presented and undoubtedly will be put to good use.

Machinery and Equipment Exposition

A very important feature of this year's convention was the exceptionally attractive exposition of machinery, equipment, and supplies. Sixty-nine members of the Manufacturers Division of the National Crushed Stone Association staged what was probably the finest show of its kind ever assembled for the edification of stone producers. Many producers stated that the privilege of seeing this show was in itself worth the cost of the trip to Chicago.

P. E. Heim Elected President

At the annual business meeting the Nominating Committee, of which E. V. Scott was chairman, presented the name of P. E. Heim, Vice President of the Carbon Limestone Company, Lowellville, Ohio, in nomination for President of the Institute for the ensuing year. In making the nomination, Mr. Scott said, "This man helped from the very beginning to organize the Agricultural Limestone Institute. He

H. A. Clark
Consumers Co.
Chicago, Ill.
North Central Region

P. E. Heim
Carbon Limestone Co.
Lowellville, Ohio
President
Agricultural Limestone Institute

A. K. Hausmann
Kelley Island Lime & Tran'port Co.
Cleveland, Ohio
North Central Region

EXECUTIVE COMMITTEE

of the

AGRICULTURAL LIMESTONE INSTITUTE

for the year 1950

H. C. Krause
Columbia Quarry Co.
St. Louis, Mo.
North Central Region

Harry E. Battin, Jr.
Callanan Road Improvement Co.
South Bethlehem, N. Y.
Northeast Region

Russell Rarey
Marble Cliff Quarries Co.
Columbus, Ohio
Representing the National Crushed Stone Association

John R. Rice
Liberty Limestone Corp.
Buchanan, Va.
East Central Region

John H. Riddle
Riddle Quarries, Inc.
Marion, Kansas
Western Region

E. V. Scott
Southwest Stone Co.
Dallas, Texas
Southern Region

AMONG THE NEWLY ELECTED MEMBERS OF ALI BOARD

L. R. Falk
L. R. Falk Construction Co., St. Ansgar, Iowa

R. P. Immel
American Limestone Co.
Knoxville, Tenn.

K. K. Kinsey
Concrete Materials and Construction Co.
Cedar Rapids, Iowa

W. H. Margraf
Marble Cliff Quarries Co.
Columbus, Ohio

Maynard Tweed
Landers-Norblom-Christenson Co.
Minneapolis, Minn.

R. M. Wille
Inland Lime and Stone Co.
Manistique, Mich.

R. T. Willingham
Willingham-Little Stone Co.
Atlanta, Ga.

has been a member of its Board of Directors from the start and has given unstintingly of his time and sound counsel in guiding its destinies. He is at all times a willing worker and has never said 'No' when asked to serve on committees or perform any of the many tasks requested of him." Mr. Heim was elected by acclamation and, in accepting the office, he expressed his thanks and appreciation for the honor which was bestowed upon him. He offered the wholehearted cooperation of the Institute to state associations in the solution of their problems whenever possible. He stated that it is his goal to increase the Institute membership during the coming year.

Five Regional Vice Presidents were nominated and unanimously elected as follows:

Northeast—H. D. Brigstocke
East Central—Verne C. Morgan
North Central—W. E. Hewitt
Southern—C. M. Sims
Western—John J. Stark

The following list, including the President, five Regional Vice Presidents, and a member of the Executive Committee of the National Crushed Stone Association, comprises the complete Board of Directors which was elected to serve until the next annual meeting:

Board of Directors

P. E. Heim, *Chairman*, Carbon Limestone Co., Lowellville, Ohio

Northeast Region

Harry E. Battin, Jr., Callanan Road Improvement Co., South Bethlehem, N. Y.
H. D. Brigstocke, Thomasville Stone & Lime Co., Thomasville, Pa.
Otho M. Graves, General Crushed Stone Co., Easton, Pa.

East Central Region

W. F. Childs 3d, Harry T. Campbell Sons' Corp., Towson, Md.
S. B. Downing, Jr., Central Rock Co., Lexington, Ky.
R. P. Immel, American Limestone Co., Knoxville, Tenn.
Verne C. Morgan, Kentucky Stone Co., Inc., Louisville, Ky.
John R. Rice, Liberty Limestone Corp., Buchanan, Va.
B. F. Taylor, Cowan Stone Co., Cowan, Tenn.
F. G. White, M. J. Grove Lime Co., Stephens City, Va.

North Central Region

H. A. Clark, Consumers Co., Chicago, Ill.
L. R. Falk, L. R. Falk Construction Co., St. Ansgar, Iowa
J. L. Fay, Material Service Corp., La Porte, Ind.
A. K. Hausmann, Kelley Island Lime & Transport Co., Cleveland, Ohio
W. E. Hewitt, East St. Louis Stone Co., East St. Louis, Ill.
K. K. Kinsey, Concrete Materials & Construction Co., Cedar Rapids, Iowa
H. C. Krause, Columbia Quarry Co., St. Louis, Mo.
B. G. Lindenfeld, Terminal Materials Co., St. Joseph, Mich.
W. H. Margraf, Marble Cliff Quarries Co., Columbus, Ohio
R. E. Meshberger, Meshberger Stone Co., Inc., Columbus, Ind.
Paul B. Nauman, Dubuque Stone Products Co., Dubuque, Iowa
A. Overgaard, A. Overgaard Rock Products, Elroy, Wis.
N. F. Schwarz, Pontiac Stone Co., Decatur, Ill.
W. J. Stoffel, Dolese & Shepard Co., Chicago, Ill.
W. E. Stone, Piqua Stone Products Co., Piqua, Ohio
Maynard Tweed, Landers-Norblom-Christenson Co., Minneapolis, Minn.
Richard M. Wille, Inland Lime & Stone Co., Manistique, Mich.

Southern Region

Chas. E. Baxter, Jr., Batesville White Lime Co., Batesville, Ark.
E. V. Scott, Southwest Stone Co., Dallas, Texas

Meeting of Newly Elected ALI Board of Directors
The Stevens, Chicago, Illinois, February 3, 1950

C. M. Sims, Campbell Limestone Co., Gaffney, S. C.
R. T. Willingham, Willingham-Little Stone Co., Atlanta, Ga.

Western Region

John H. Riddle, Riddle Quarries, Inc., Marion, Kans.
John J. Stark, Girard, Kans.
D. P. Thomas, Fort Scott Hydraulic Cement Co., Fort Scott, Kans.

Representing the National Crushed Stone Association

Russell Rarey, Marble Cliff Quarries Co., Columbus, Ohio

New Board Meets; Executive Committee Elected

The newly elected Board of Directors held its first meeting the afternoon of February 3 and elected an Executive Committee composed of the following members:

Harry E. Battin, Jr. — H. C. Krause
H. A. Clark — John R. Rice
A. K. Hausmann — John H. Riddle
E. V. Scott

Also included on the Executive Committee as ex officio members are P. E. Heim, President of the Institute, and Russell Rarey, representing the National Crushed Stone Association.

The Board elected H. A. Clark and H. C. Krause to serve with President Heim as representatives of the Agricultural Limestone Institute on the Board of Directors of the National Crushed Stone Association. J. R. Boyd was re-elected Secretary-Treasurer.

Joint Session of ALI and NCSA for Operating Men and Equipment Manufacturers—The Stevens, Chicago, Illinois, February 1, 1950

Co-Chairmen: Standing left to right—G. D. Lott, Jr., Palmetto Quarries Co., Columbia, S. C.; Marvin Nelson, Concrete Materials and Construction Co., Cedar Rapids, Iowa

Panel Members: Seated left to right—W. H. Ruby, Acme Limestone Co., Fort Spring, W. Va.; Nelson Severinghaus, Consolidated Quarries Corp., Decatur, Ga.; F. H. Edwards, New Haven Trap Rock Co., New Haven, Conn.; E. F. Haberkern, Columbia Quarry Co., St. Louis, Mo.

Agricultural Limestone Institute General Luncheon, The Stevens, Chicago, Illinois, February 2, 1950

More Durable Asphaltic Concrete Pavements*

By RAYMOND HARSCH

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WHEN Mr. Goldbeck invited me to give a talk on asphaltic concrete pavements, I recalled that this subject was ably discussed at your last year's convention by E. F. Kelley.[1] Mr. Goldbeck must believe in the value of repetition as a factor in learning, as the presentation of my thoughts on this subject must necessarily include many of the factors contained in the previous paper. Having been taught in my College English Course that any theme should have unity, emphasis and coherence, I trust that this presentation will qualify in at least one, namely, emphasis.

Extensive research to determine the several factors which influence the success of asphaltic pavements and the publication of these data have created in the minds of many engineers a feeling that the technical aspects of proper design are so numerous and complicated that successful work can only be accomplished when there is available a highly trained technical and research organization to solve the many intricate relationships between asphalts and mineral aggregates. We are prone to concentrate our attention on the occasional failure, which looms large because it is a failure, and overlook the thousands of examples of satisfactory pavements, many of which were constructed twenty to thirty years ago and are still rendering good service.

Take for example, the matter of flexible pavement thickness design. Theories on this subject have been published by Hubbard,[2] Goldbeck,[3] McLeod,[4] Vokac,[5] Smith,[6] Hveem,[7] and Hanson,[8] to name a few. All arrive at slightly different answers as to what thickness of base plus surface is necessary over a particular subgrade for a given wheel load. As all of the formulas are necessarily based upon the supporting value of the subgrade soil, one would think that there would be some standardized procedure for obtaining this basic information. Apparently, however, there is as yet no agreement as to how the bearing value of the soil shall be determined and at what moisture content or degree of compaction.

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Assuming a given bearing value and using this in the several formulas for thickness design, it is doubtful if, for present day highway loadings, the resultant values of thickness will differ by more than two or three inches. Considering the number of assumptions that are made, are we not trying to design pavement thicknesses with too great an accuracy? For most engineering structures the design allows for a factor of safety. Why should not a factor of safety be introduced in thickness design for highway surfaces which, before the expiration of their useful life, are usually subjected to traffic loads far heavier than those used in the original design calculations? Also, depending upon climatic and moisture conditions, it is often impossible to obtain in the field the compaction and moisture content in the subgrade which will produce the bearing value assumed in the original calculations.

By the use of one or more of these design formulas, many engineers are specifying pavement structures of adequate thickness for present day traffic conditions. Unfortunately, thickness of base does not alone assure adequate support to the wearing surface or proper distribution of loads to the subgrade. Too often the base course material contains sufficient clay or other fines which become plastic when wet, forming a lubricating coating on the mineral particles and reducing the friction between them. All two frequently the base course consists of material of large or uniform size rock or gravel having a high void content which is placed directly on the subgrade soil. If the subgrade soil becomes plastic or liquid when wet, it gradually intrudes into the voids of the aggregate under the vibration action of traffic and causes a reduction in the supporting value and, therefore, the effective thickness of the base course. This phenomenon and the remedy therefor have been known for years but have been accepted by only a small percentage of the engineers. The remedy consists of blanketing the plastic type of subgrade soils with a layer of fine granular material such as sand, crushed rock screenings, granulated slag, etc., so as to fill the voids in the lower portion of any open-graded aggregate, thus preventing the intrusion of plastic or liquid clay soil.

The foregoing has emphasized that the base course should preferably be of granular material and of

maximum density—with the fine portion free of clay or other binder which would be adversely affected by moisture. With such a base course of proper thickness for the particular type of subgrade soil and the traffic load, the bituminous wearing surface may be anything from a light bituminous surface treatment to a 3-in. asphaltic concrete pavement. There are many, many miles of the former which are still giving good service after twenty years of traffic; however, these lighter types of surface are not a part of this discussion. The remaining remarks will concern asphaltic concrete wearing surfaces.

Assuming an adequate base which will insure the asphaltic concrete pavement from failure due to improper foundation support, full attention can be given to the design and composition of the asphaltic concrete paving mixture.

The use of the term "mixture" eliminates the asphaltic surfaces constructed by spraying or penetration methods; however, some of the features of this type surface will be compared with the mixture type in the following remarks. The nature of the asphaltic binder will be given first attention. This will be restricted to asphalt paving cements which fall in the consistency range of 40–300 penetration at 77 F. As these asphaltic binders are liquefied for use by means of heat, in contrast to the addition of solvents or water as in the case of cutback asphalts and emulsions, it can be expected that upon cooling they will assume their initial consistency.

What Grade of Asphalt Cement?

Despite many thousands of examples of asphaltic concrete pavements made with asphalt cements of various consistencies from 40–50 to 200–300 penetration, all of which perform satisfactorily, there is still a widespread opinion among engineers that if a soft grade of asphalt is used the resulting pavement will bleed and shove; whereas, if the asphalt is hard the pavement will remain stable in hot weather and resist movement. Experience during the war years, when the available asphalt cements were restricted to six grades, demonstrated that no more than four grades of paving asphalt cement would adequately serve all demands for this type of binder. This is further confirmed by a recent survey by The Asphalt Institute of the percentage of the various paving grades between 40 and 300 penetration used during 1948. This survey showed that 41 per cent of the paving grade asphalts used was of 85–100 penetration, 21 per cent of 150–200 penetration and 12 per cent of 200–300 penetration. As nearly all of the grades above 120 penetration were utilized for surface treatments, armor coats, penetration macadams and similar sprayed applications, it can almost be said that one grade of paving asphalt would be sufficient for all asphaltic concrete construction. The consistency of asphalt is related to temperature. Figure 1 shows the penetration versus temperature

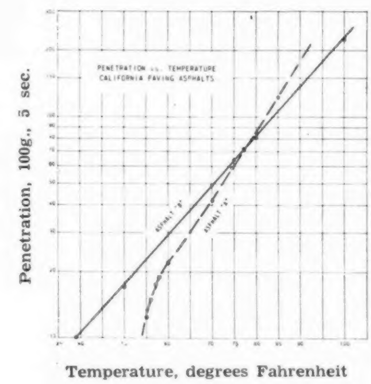


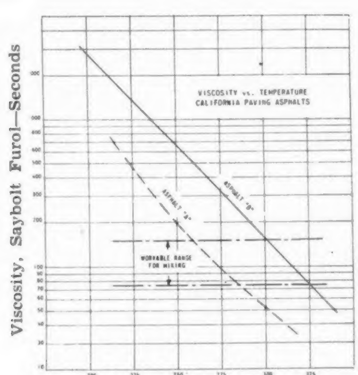
FIGURE 1

relationship of two California asphalts of different characteristics. Asphalt "A" is of low asphaltene content and quite susceptible to temperature. Asphalt "B", produced from a high sulfur crude, with a relatively high asphaltene content and being less susceptible to temperature, resembles the Mexican type asphalt extensively used in the Midwest prior to the war. Both types of asphalt are used in large volumes west of the Rocky Mountains with excellent results.

It will be seen that less than 5 F. change in temperature will produce a change in consistency in the asphalt from one grade to the next. Since many tests have shown that an asphaltic surface attains a temperature of above 140 F. under exposure to the summer sun and yet has to carry the same if not heavier traffic while at that temperature, one can readily see that the asphalt would offer little resistance to movement even though the hardest grades were used. Yet pavements made with either of these asphalts will be satisfactory if the stability is in the mineral aggregate which, incidentally, comprises 90–95 per cent of the mix. Another point which might be mentioned is the hardness of these asphalts as the temperature gets lower; therefore, the softer the asphalt originally selected, the better the chance

of resisting brittleness at cold temperatures and the greater the margin of safety against hardening when mixed with hot aggregate in the paving plant.

This latter situation should receive considerably more attention than it is now given. In the mixing process, the mineral aggregate and asphalt are both heated to facilitate rapid coating of the particles with a uniform film of asphalt and to produce a final mixture which is sufficiently workable to be placed on the street by mechanical spreaders and finishing machines. Exposure of the asphalt cement in thin films on rock at elevated temperatures to air during mixing causes oxidation and consequent hardening of the asphalt. The extent of hardening depends upon the nature of the asphalt and the degree of exposure to heat and air. Modern finishing machines enable these mixtures to be placed at lower temperatures than would be the case for hand placing and raking and also permits the use of mixtures of low sand content without undue segregation of coarse and fine particles. As exceedingly high temperatures of mixing are therefore no longer required, it is important that the mineral aggregate temperature does not exceed 350 F., which is considered the critical temperature for rapid oxidation of asphalt. A reference to Figure 2 will show the viscosity vs.



Temperature, degrees Fahrenheit

FIGURE 2

temperature relationship of the two asphalts "A" and "B". It will be noted that asphalt "A" attains a given viscosity or fluidity at a temperature approximately 35 degrees lower than is required for asphalt "B". This means that mixtures made with "B" asphalt must be 35 degrees higher in temperature than mixes made from asphalt "A" to have the same workability. Unfortunately, asphalt "B" is more susceptible to oxidation at a given temperature than is asphalt "A" and the higher temperature works to the detriment of asphalt "B" as regards hardening.

Stability of Mixes

The foregoing should be convincing evidence of the fallacy of depending upon the asphaltic binder to provide the necessary stability in the mix to resist shoving under traffic. At low temperatures it may contribute some resistance to displacement under fast moving or suddenly applied loads, but summer conditions cause the asphalt to act as a lubricant, reducing the friction between the surfaces of the mineral aggregate particles which are in contact. The primary dependence for stability, therefore, should be on the mineral aggregate characteristics of angularity, surface roughness, and particle size distribution. These factors are interrelated and must be considered together.

Angular aggregate such as crushed rock, crushed slag, and crushed gravel generally provide higher stability than uncrushed gravel because of the ability of the particles to interlock and the fact that the freshly crushed surfaces are of rougher texture than generally occur on water-worn gravel. Mineral aggregates produced by crushing, therefore, usually provide adequate stability regardless of the gradation. This is well illustrated by the stability attained with penetration macadam and open-graded mixes having very small amounts, if any, of particles smaller than 10-mesh size.

Uncrushed gravels which may or may not have rough surfaces and do not possess angularity to provide interlock usually require a minimum amount of intermediate and fine sizes to secure additional points of mineral contact to provide the required frictional resistance.

The stability of both crushed and uncrushed coarse aggregate can be seriously reduced in a mix by having present a high percentage of intermediate sizes which spread the coarser particles apart, thus creating additional voids which must, in turn, be filled with finer sizes. When the content of fine material is above that required to fill the voids in the compacted coarse particles the stability of the mixture is then primarily the stability of the fine aggregate-asphalt mortar.

For too many years maximum density of asphaltic concretes has been the prime objective of paving engineers. In attempting to attain this goal they

have overlooked the characteristics which make asphalt pavements superior to other types, namely, flexibility and durability. It is agreed that for a given mineral aggregate the greater the density obtained by a scientific gradation of particle sizes, the greater the stability obtained. Maximum stability, however, is not the only desirable characteristic for asphaltic concrete pavements and much of the hard-

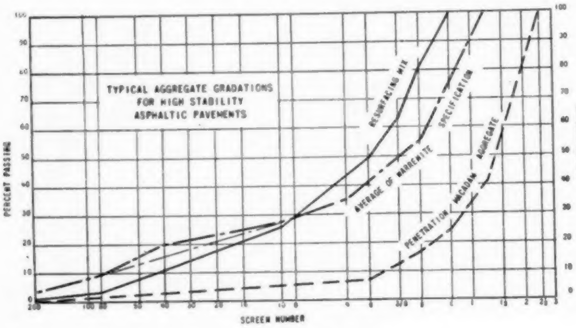


FIGURE 3

ening, cracking, and stripping which is prevalent in recently laid pavements could be the result of attempting to secure maximum density in the mineral aggregate despite the fact that adequate stability may have been obtained with a high void content mix.

Producers of crushed rock would be the last to agree that asphalt penetration macadam surfaces do not have adequate stability. A grading curve of a typical asphalt macadam aggregate is shown on the grading chart, Figure 3. Attention is called to the large maximum size of 2 1/2 in. and the very low percentage of material passing 1/4 in. Such an aggregate obviously has a very low surface area in square feet per pound of aggregate and yet the several applications of asphalt totaled 6.15 per cent by weight of the aggregate and most of this asphalt was retained in the top half of the 3-in. surface. Obviously, the void content of the pavement is much higher than normally permitted in an asphaltic concrete mix and the asphalt films on the aggregate are much thicker, yet the pavement has adequate stability.

Remembering the "inherent stability" slogan of the Warrenite paving promotion of the early '20's, a copy of their printed standard specification was studied. The gradation of mineral aggregate conforming to the middle of their specification limits is shown on Figure 3. It will be noted that the percentage passing 10 mesh screen is 27 and although the specification allowed a maximum of 35 per cent passing No. 10, the inspectors made every effort to keep this percentage at the minimum, thus obtaining the maximum contact between the coarser particles to develop maximum stability. Attention is also called to the low percentage of dust and filler passing 200 mesh required by this dense graded mix. This specification called for 5 to 8 per cent by weight of asphalt cement or an average of 6 1/2 per cent. The specification also required that the mineral aggregate shall not be heated to a temperature exceeding 375 F. which temperature, if properly enforced, would prevent excessive hardening of the asphalt cement when subjected to contact with air while in thin films on the hot aggregate. Asphaltic pavements of this type have been in use thirty years and have not shown the instability, cracking, or water stripping that some of the more recent pavements have revealed.

With the discontinuance by many cities of street cars and the substitution therefor of trackless trolleys or motor buses, some of the existing asphaltic pavements are beginning to shove and develop corrugations at street intersections where the buses stop. The heavier loads and the thrust action caused by the acceleration and deceleration of this type of traffic is often beyond the stability of many asphaltic paving mixtures. Upon examination it will be found that such mixes are usually over-sanded, over-asphalted, of low void content, and often containing a high percentage of the sand portion of an intermediate size. These mixes when originally laid may have had sufficient voids in the mineral aggregate to allow for the quantity of asphalt used, but under the compacting action of traffic they have been consolidated until the asphalt is in excess of the voids. Often this excess asphalt is flushed to the surface, causing the undesirable slipperiness and skidding properties so often complained of by motorists.

That adequate stabilities for asphaltic mixes subject to bus traffic can be attained is illustrated by the satisfactory performance of many miles of asphalt resurfacing in several major cities on the West Coast. Much of this asphalt resurfacing is over old sheet asphalt, brick, stone block, or concrete paving, which had deteriorated to the point where resurfacing was necessary to reduce maintenance costs of both the pavement and the motorized equipment. As these old bases were badly cracked and often of heterogeneous composition, it was essential that the resur-

facing mix be sufficiently flexible to absorb any minor movements and prevent the underlying cracks from coming through to the surface. As some of the cities are located in the Pacific Northwest where the rainy season lasts nine months of the year with occasional freezing in the winter months, the mixes must withstand water action. All of the conditions of stability, flexibility, and durability (resistance to cracking and stripping) have been met by a pavement of 2-in. minimum compacted thickness consisting of crushed rock or gravel of 3/4-in. maximum size with 20 to 25 per cent passing the 10 mesh screen and containing 5 to 6 per cent asphalt. These mixes have a high void content when initially placed (approximately 15-18 per cent), but under the consolidation of traffic this is reduced to possibly 10 per cent. The aggregate grading of this resurfacing mix is shown on Figure 3. On the next chart, Figure 4, is shown the limits of the aggregate for a dense-graded asphaltic mixture as given in a discussion of this subject by F. N. Hveem[9] of the California Division of Highways. The comments pertaining to conditions which would prevail if the aggregate grading extended beyond these limits are quite pertinent and should be thoroughly appreciated by engineers. A mineral aggregate having a grading curve falling within these limits, however, is considerably different than the ones which have just been discussed. For example, such an aggregate would have approximately 43 per cent passing the 10 mesh screen and 9 per cent passing the 200 mesh screen. The surface area per pound of such an aggregate would be approximately 4000 sq. ft. as compared to 2200 sq. ft. for the Warrenite, 1500 sq. ft. for the resurfacing mix, and 400 sq. ft. for macadam. It is very seldom that such a dense aggregate permits the incorporation of more than 5 per cent of asphalt, with the result that the asphaltic films coating the mineral particles are much thinner than those present in the other mixes. It is these extremely thin films of asphalt which contribute to the rapid oxidation and hardening of the asphalt, causing embrittlement of the mix, and to stripping action by water. It should be apparent that the mineral aggregate particles in mixes containing very thin films are not subject to adjustment on each other without the possibility of breaking such film bond. These very dense mixes tend toward rigidity, with the result that very slight deflections of the pavement surface, particularly under repetitions of load, cause early failure by the development of alligator-type cracking. Of interest is the fact that the California specifications call for an average grading below the lower limit curve. It has often been stated that for greatest durability an asphaltic concrete mix should contain the maximum amount of asphalt which can be incorporated in it without producing instability. If, therefore, an aggregate possesses adequate stability with a somewhat open

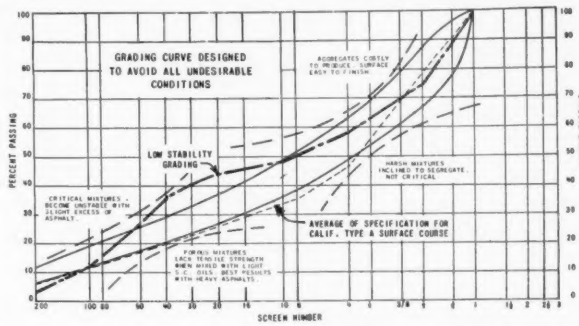


FIGURE 4

grading its use in a mix permits a higher percentage of asphalt and hence a more durable pavement. In other words, substitute asphalt for a portion of the fine aggregate, particularly the high surface area fines.

Stripping

Stripping is the failure of asphalt films to adhere to the surface of mineral particles in the presence of water or moisture vapor. This is sometimes due to the greater affinity of the mineral for water than for asphalt. This matter of stripping has been receiving a tremendous amount of attention from the highway engineer and research laboratory, which interest is to a large extent kept alive by the promotion activities of the representatives of companies manufacturing so-called "anti-stripping additives."

Very little was heard of asphalt stripping in the days of the penetration macadam, sheet asphalt, and Warrenite paving era, when practically all bituminous pavements were made with hot asphalt cements. Stripping was first observed in the mixed-in-place surfaces where liquid asphalts of the road oil type were used. Such asphaltic mediums were of low viscosity and low specific gravity and were often readily floated to the surface of the pavement by moisture. The development of cutbacks of asphalt cements and lighter solvents improved the resistance of the liquid binders to stripping, provided a sufficient curing time occurred before wet weather to permit

the volatilization of the solvent. Even then, the asphalt films left by the cutback are extremely thin and not very waterproof. Furthermore, during the war, the demand for highways and airports caused engineers to extend the length of the construction season by starting work earlier in the spring and continuing it later into the fall where wet and cold weather conditions contributed to over-heated mixes, poor compaction, and other difficulties. It is quite possible that these anti-stripping agents are being expected to overcome deficiencies in the selection of materials, design of mixes, and faulty construction procedures. There are, undoubtedly, some types of aggregate which do not retain an asphalt film in the presence of water regardless of the type of mix or the care used in its preparation. These aggregates, however, must be very rare as it is difficult to find a penetration macadam or an asphaltic concrete surface constructed during seasonable weather and under generally approved conditions of construction which has failed because of stripping.

Some reports claim that the asphalt cement in the lower portion of the pavement has been stripped from the aggregate and flushed toward the surface. Is it not possible that the presence of a clay binder in the base course, together with any moisture present, may produce an emulsifying action on the asphalt under the vibration of traffic? If such is the case, then it is only necessary to provide a non-plastic granular base immediately under the asphaltic surface to prevent the trouble. Having the top portion of the base course granular provides drainage for any free water which may occur under the asphaltic surface.

Summary

In conclusion, I wish to summarize the principles which, if adopted and generally practiced, would greatly extend the useful life of asphaltic concrete pavements.

(1) Provide an adequate thickness of *effective* flexible foundation or base to support the expected traffic loads over the particular subgrade.

(2) By *effective* flexible base is meant one constructed of granular, densely graded, mineral aggregate such as crushed stone, sand-gravel, crushed slag, etc., having non-plastic fines. Open-graded aggregate bases require the subgrade soil to be blanketed with a layer of fine, granular aggregate such as sand, crusher screenings, granulated slag, etc., prior to placing.

(3) The base course immediately beneath the asphaltic mix should be of densely graded crushed stone, crushed gravel, or slag, containing sufficient fine granular material to permit compaction without the incorporation of any clay or similar binding material.

(4) Consider the asphalt cement only as a waterproof binder supplying the cohesion necessary to prevent raveling of the mineral aggregate and to provide flexibility to the pavement.

(5) Secure stability in the pavement by the proper selection of mineral aggregates bearing in mind that the angularity, surface roughness, and size gradation of the mineral particles influence the frictional resistance of the aggregate to displacement.

(6) Incorporate the maximum amount of asphalt cement with the mineral aggregate to provide the thickest asphalt coatings which will not appreciably reduce the friction in the aggregate.

(7) Select a reasonably soft asphalt cement and insure it against hardening during mixing with the hot mineral aggregate by rigidly controlling the aggregate temperature below 350 F.

(8) Construct the asphaltic concrete pavement under climatic conditions which will permit a reasonable period of workability in the mix for proper laying and compaction.

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Aggregates and Their Influence on the Durability of Concrete*

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THE work of our organization has been devoted to many fields of highway activity over the past thirteen or fourteen years, including work in traffic and economics, pavement design, and we do a great deal of work in materials research. This latter work is of a character which, in part, will be of much interest to you.

The literature contains numerous references regarding the correlation between the performance of Portland cement concrete pavements and the source of coarse aggregates used. Gibson[1] in 1938 reported on the extensive occurrence of mapcracking and he related this failure to the source of coarse aggregate used in the concrete. In the same article Gibson showed that this type of disintegration could be reproduced in the laboratory by a series of wetting and drying tests. In 1942 Jackson and Kellerman[2] reported the results of an extensive series of laboratory tests in which some of the aggregates reported by Gibson[1] were used, and the authors recommended that certain of the aggregates tested not be used as concrete aggregate unless blended with some additional material of satisfactory service record. In regard to aggregates in the Ozark regions Axon, Willis, and Reagel[3] state that "use of certain coarse aggregates has been found to be the principal cause for the inferior resistance to freezing and thawing of some concrete pavements in Missouri." These conclusions were reached as a result of data obtained from "periodic observations and maintenance records of some thousand miles of pavement in service." Cantrill and Campbell[4] showed correlation between pavement performance and the source of the coarse aggregate used in the concrete in Kentucky. Furthermore, the authors proposed two specifications for the control of the coarse aggregate with unsatisfactory service record by the elimination of aggregates with absorption above 3 per cent for use in concrete and by specifying a maximum permissible reduction in flexural strength of concrete beams subjected to cycles of freezing and thawing. Moyer[5] showed correlation between performance of some Iowa pavements and the source of coarse aggregate employed. He reported volume change, blowups, and a general tendency toward unsoundness of pavements constructed with LeGrand limestone, despite the fact that unsoundness was not indicated by "the usual laboratory freezing and thawing soundness tests."

The data available on performance of Portland cement concrete pavement in service show rather conclusively that the coarse aggregate variable is frequently an important one. The use of certain siliceous gravels and certain limestones, particularly some argillaceous limestones, should be approached with caution. It is fortunate that in the regions where these materials with inferior performance records occur, materials of excellent quality usually are abundant. For the producer of stone it is important that he realize that the coarse aggregate component is an important one and, as a result, he should check his sources of supply for durability characteristics before making large investments in quarries of unknown quality.

Aggregate Tests

In 1923 Abrams[6] wrote that "the strength and durability of concrete depend to a large degree upon the quality of concrete and only to a minor degree upon the characteristics of the aggregates used." This statement is still true in general, although experience has shown that there exist some outstanding exceptions, several of which have already been listed in this paper. The testing of aggregates from the standpoint of predicting their durability characteristics when used in concrete still remains a problem without an exact solution.

As to mineralogical composition of aggregates, Loughlin[7] stressed the fact that clay minerals are the most objectionable of all which may be found in rocks and especially in concrete aggregate. He stated that "their tendency to absorb moisture is

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their bad feature." As early as 1930 Jackson[8] stressed the need for both field and laboratory research in an effort to evaluate the durability characteristics of aggregates as these characteristics pertain to the performance of Portland cement concrete pavements. He mentioned the possibility of concrete failures caused by a difference in the thermal characteristics

FIGURE 1
A Blowup on an Airport Pavement

of the aggregates as compared with the thermal characteristics of the manufactured concrete. Pearson[9] correlated a certain type of failure in exposed concrete with the thermal properties of the aggregates used. In 1929 McMillan and Ward[10] stressed the fact that both the physical and mineralogical characteristics of aggregates are important factors in the durability of concrete. They stressed the importance of porosity of the aggregate, and they mentioned the deleterious effect of using argillaceous limestones in Portland cement concrete.

A great deal has been written about methods of tests which might be used for evaluating the durability characteristics of aggregates when used in concrete. McCown[11] in 1931 reports an assemblage of data from many laboratories, particularly in regard to the significance of the sodium sulphate and freezing and thawing tests on mineral aggregates. In this assemblage, Bert Myers of Iowa reported inferior field results in the use of the Cedar Valley limestone in concrete—the losses in both sodium sulphate and freezing and thawing tests were likewise high. In the same publication, Illinois reported poor resistance to the sodium sulphate soundness test of Cedar Valley limestone in Illinois, and mention is made of at least one serious failure—a concrete bridge constructed with this same aggregate. In this same report[11] Scholer intimates that unsound aggregates can be identified by testing laboratory-made specimens when he states that "tests of aggregate should include tests in concrete before any source is condemned." Not too different in characteristics, perhaps, is the Kokomo limestone in Indiana (upper Silurian) which has a notoriously bad performance record. However, in the case of the Kokomo limestone, sodium sulphate tests do not always show the material to be unsound.

In the 1927 report of ASTM Committee C-9 on Concrete and Concrete Aggregates[12] the usefulness of the sodium sulphate soundness tests was questioned from the standpoint of interpretation of results, while Gibson[13] indicates a correlation between accelerated soundness tests of aggregates and field service in the case of some aggregates and a negative correlation in other cases. He concludes that "freezing and thawing are a much better measure of the behavior of aggregates in service." Kriege[14] reported the results of a critical study made on the testing techniques used in connection with accelerated soundness testing.

In 1939 Goldbeck[15] stated that certain factors regarding aggregates and regarding conditions of exposure are being overlooked in connection with lab-

FIGURE 2
A Blowup on an Indiana Pavement

oratory investigations of soundness. Withey[16] discussed the various factors which are involved in performing freezing and thawing tests while Reagel[17] discussed the relationship between field exposures of concrete pavements in Missouri and accelerated durability tests. Scholer[18] as early as 1928 stated

that "alternate freezing of saturated concrete at low temperatures and thawing at room temperatures is a valuable means of studying the durability of concrete and concrete aggregates and is worthy of further study," thus indicating the importance of moisture content in evaluating the durability characteristics of aggregates as well as concrete. He stated further in the same article that "the use of unsound aggregate produces unsound concrete." Walker[19] stated that "the evidence now before us indicates considerable promise for freezing and thawing tests of concrete as a measure of aggregate durability."

There appears to be much confusion as to what accelerated soundness tests reveal in regard to predicting the performance of coarse aggregates when used in Portland cement concrete. The published data show a moderate amount of correlation between accelerated soundness test results and field performance, but the exceptions are sufficiently numerous to indicate that presently-employed methods of test and many commonly used specifications are not entirely adequate to fully evaluate aggregates for use in Portland cement concrete.

Indiana Field Studies of Concrete Durability

In 1942 the Staff of the Joint Highway Research Project was asked to make a performance survey of the rigid pavements located on the primary highways in Indiana. The survey was intended originally to add to the store of knowledge on subgrade soils as it pertained to the design of rigid pavements. As the survey progressed, it was found that not only could the soils be reasonably-well evaluated by such a survey, but that items of design, construction, and materials played an important role in performance evaluation.

Most of the performance survey data were collected by T. E. Shelburne, now Director of Research, Virginia Department of Highways, and the writer. The data on correlation between performance characteristics and the source of coarse aggregate were reported in 1946 at the annual meeting of the Highway Research Board.[20] At a little later date Sweet and Woods[21] reported on the influence of soil textures and the durability characteristics of concrete pavements constructed with inferior aggregates.

One of the peculiar types of failures which came to the attention of those making the field surveys was that of pavement blowups. The literature contains very little information in regard to this phenomenon, although it has been generally assumed that blowups are caused by excessive expansion caused by moisture and high temperatures. An early reference to blowups is found in 1925 in an Engineering News-Record article in which it is concluded that the cause of blowups is somewhat a matter of speculation. The article states that "the most frequent occurrence of blowups is when a hot day is followed by a rainy night, succeeded by another hot day, causing both temperature and moisture expansion."

Fortunately, the Maintenance Department of the State Highway Commission of Indiana had kept good records in regard to blowups in Indiana. Through these data it was possible to evaluate this type of failure. In general, the data showed that most blowups occurred at about 2:30 in the afternoon at a temperature of about 93 F. or above. In regard to precipitation, a tendency was indicated toward the occurrence of a greater number of blowups when periods of high temperature occurred in the early summer and generally wetter months. In contrast, high temperatures in August, when accompanied by low rainfall had less effect on the occurrence of blowups.

More important than the climatic factor in evaluating blowups was the decided absence of blowups in certain sections of concrete pavement. While making the surveys, projects were encountered in which the evidence of previous blowups was to be found in patched-over areas at frequent intervals, i.e., 1/10 of a mile, 500 ft., etc. This pattern would, on occasion, change suddenly, and no evidence of blowups could be found. A detailed check of records would invariably show a relationship between this performance information and the source of the coarse aggregate incorporated in the concrete. Similarly, adjacent contracts would frequently show a blowup tendency on one stretch of road and no evidence of blowups on another.

A total of 3300 miles of pavement were surveyed in Indiana in 1943 and 1944, including 2623 miles constructed between 1921 and 1934, without expansion joints. The latter mileage consisted of 375 projects containing cement from 17 sources, fine aggregate from 138 sources, and coarse aggregate from 155 sources. A detailed analysis of the data showed no correlation between the susceptibility of those pavements to blow up and the source of the fine aggregates used, the time of year of construction, and traffic conditions.

In the case of coarse aggregate, the picture was entirely changed. Although there were several

sources of coarse aggregate which showed questionable performance when used in Portland cement pavements, when evaluated on the basis of blowups, mapcracking, and associated disintegration, there were five coarse aggregates which showed outstandingly poor performance. These five coarse aggregates were used in 284 miles of pavements (about

FIGURE 3
Excellent Performance of Pavement in Immediate Foreground Is in Contrast to Poor Performance Near Bridge. Changes in Performance Also Indicate Changes in Coarse Aggregate

11 per cent of the mileage included in the study) in which 1168 blowups occurred, or about 49 per cent of the total number of blowups. One of these five materials was used in 23 projects, in combination with six different cements and eight different fine aggregates. Every one of these 23 projects studied contained blowups ranging in number from 0.17 to 25.3 per mile, with an amazing average of 7.28 per mile. These data take on added significance when consideration is given to the fact that (1) the occurrence of blowups has led to widespread use of expansion joints, and (2) the occurrence of blowups can now be associated directly with mapcracking, general pavement deterioration, and short life.

A follow-up on the blowup survey was made in connection with an attempt to evaluate the soils variable in the occurrence of blowups. In this work it was found that blowups, mapcracking, and general disintegration were of much less importance on those pavements constructed on pervious sand or gravel than were those constructed on impervious claylike soils. This observation led to the deduction that moisture in the pavement was the immediate cause for this type of pavement failure since silty-clay soils tend to hold water in the concrete pavement and sand soils present a well-drained subgrade.

Laboratory Studies

The field performance surveys led to the initiation of extensive laboratory studies. In the laboratory work, effort has been placed on the development of procedures which would produce laboratory concrete of inferior quality when made with aggregates of inferior performance rating, and concrete of good quality when made with aggregates of good performance rating. With the field surveys indicating the variable of moisture content as being a significant one, attempts were made in the early stages of the work to evaluate this variable. Thousands of concrete beams were molded, and the aggregates with both good and bad performance records were vacuum-saturated before they were incorporated in the beams. These beams were cured and were then subjected to cycles of freezing and thawing and, in some instances, to cycles of wetting and drying and heating and cooling at temperatures above freezing. In a relatively few number of cycles, elongation of beams (similar to blowups in the pavement), mapcracking, and loss of strength as measured by a severe reduction in dynamic modulus, occurred in the

FIGURE 4
Severe Distress of a Pavement Caused by the Use of Poor Aggregates

beams made with aggregates of questionable quality. In contrast, those beams made with aggregates of good-performance rating were able to withstand hundreds of cycles without indicating signs of distress.

Fortunately for Indiana, the sources of supply of aggregates with good durability characteristics are

far in excess of those with inferior performance ratings. The aggregates with bad records consist of laminated dolomitic limestones, cherty limestones, high calcium limestones, and certain siliceous river gravels. These inferior materials have in common high absorption values, although it must be added that there are limestones with excellent service records in Indiana which also have high absorption values. These data indicate that the size of the voids is important in evaluating the durability characteristics of aggregates; furthermore, it is indicated that new procedures are likely to be used in the future in evaluating the durability characteristics of aggregates used in Portland cement concrete.

Conclusions

In the case of Indiana aggregates, a large amount of laboratory testing has been performed. Information on the durability characteristics of concretes and Indiana aggregates is incomplete. Several laboratory and field studies are still under way, and additional studies are being planned. However, the data now available justify the following general conclusions regarding Indiana aggregates (similar to recommendations made by K. B. Woods and D. W. Lewis at the 1949 Purdue Road School):

1. The effect of freezing and thawing of concrete containing aggregates in a near-saturated condition is the primary factor in their lack of durability in Indiana concrete. The pore or void characteristics of these aggregates apparently determine their total absorption characteristics.
2. Correlation of aggregate characteristics with field performance records justify the use of new quality specifications of crushed stone for concrete aggregate in Indiana. Some important requirements might well include one or more of the following items:
   a. A low percentage of voids with diameters less than 0.005 mm.
   b. Some limitations on the absorption and degree of saturation values of the aggregates tested by vacuum.
   c. The use of freezing and thawing test results obtained on concrete in which the aggregates are incorporated with a moisture condition comparable to the degree of saturation which may be attained during field use. Comparative tests might well be used, with the unknown materials compared with an aggregate of known in-service durability record. Proper control of air content and degree of saturation of the mortar is essential.
3. If, for economic reasons, it seems necessary to use a doubtful or inferior aggregate, the concrete durability may be improved by:
   a. Use of air entrainment.
   b. Drying of aggregate before incorporation in the concrete.
   c. Use of base courses, subgrade drainage, summer construction, etc., to insure that the concrete becomes and remains as dry as possible before freezing and thawing begins.

Finally, from the standpoint of producers of crushed stone, it is strongly recommended that careful checks be made on the quality of a potential quarry before actual quarrying operations are initiated. Although the number of strata containing non-durable limestone are limited in extent and represent only a small fraction of the total potentially-available supply in Indiana, the fact that some poor materials do exist warrants careful investigation of potential quarry sites by the producer.

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Perlite

FAST-GROWING infant of industrial minerals is perlite, a siliceous volcanic rock containing water that when crushed and suddenly heated pops into a very light-weight material. Heat and sound insulating properties qualify it for use in plaster, light-load bearing concretes, and prefabricated masonry units. It is also used as a filler in plastics and resins and in filtration. Only a mineral curiosity in 1940, it is now mined in several western states and shipped to more than 40 expanding plants from coast to coast. Production of crude perlite has risen from 4,200 tons in 1946 to over 15,000 tons in 1949.

Fatigue and Accidents[1]

FATIGUE may be described as a feeling of weariness following exertion, or the result of systemic conditions or mental tension. When muscles contract repeatedly, certain substances, including lactic acid, may accumulate in the tissues and are thought to be responsible for muscular fatigue. In long-sustained exertion the depletion of carbohydrates may be the controlling factor. It is common for athletes to take honey or other sugars before, and during, competition involving extreme physical effort.

In a large measure, fatigue in industry is caused by nervous tension, which may be the result of the work assigned but frequently is the result of external difficulties. Improper lighting, excessive noise, vibration, poor ventilation, unpleasant odors, insufficient work space, unpleasant surroundings, and poor housekeeping are contributing factors in fatigue.

Fatigued persons are accident prone because of reduced perception, slow reactions, and loss of the mental alertness which ordinarily perceives hazards.

The result of physical fatigue is illustrated in an accident which occurred immediately following a vigorous three-set tennis match. A cement plant worker with considerable safety training and experience noticed a board with a nail sticking up, just outside the back court fence. As was his practice around the plant, he attempted to bend the nail over with the sole of his shoe. Instead of bending, the nail penetrated the rubber sole, inflicting the usual puncture wound. In his fatigued condition this man did not reason that special care would be required to bend over a nail with a tennis shoe.

The reduction of this fatigue hazard is largely the responsibility of the foreman. He should talk to each man at the beginning of the shift and make an appraisal of his physical and mental condition. Clues indicating that a man begins his work tired or under mental strain should be followed up by further investigation and action if circumstances warrant.

Where a man is assigned some unusual task which involves mental or physical exertion, he should be observed frequently, and relief arranged for him, if the foreman deems it necessary or desirable.

"If a man is alert
He seldom gets hurt."

Russ A. Loveland, Superintendent
Pennsylvania-Dixie Cement Corporation
Nazareth, Pa.

[1] Reprinted from Cement and Quarry News Letter, March, 1950.

Federal Aid For Highways[1]

By CHARLES M. UPHAM
Engineer-Director, ARBA

EVER since 1916 the federal-aid highway expenditures of the government have been the spearhead of the highway program. Improvement of roads is called for in the Constitution. In the early 1800's the federal government contributed a small amount to road construction, but it was over a hundred years before the interest and the lessons learned were sufficient to cause legislation that would bring about standardization in highway construction and maintenance and credit highways as one of the most important media of transportation and communications.

Since 1916, with the exception of two years, the authorizations for aid to the states have been provided by Congress—generally at two-year intervals. The amounts were modest at first and were a minor part of road expenditures by the states, but for the past five years they have become sizeable and approached a half billion dollars annually. The present appraisal of this effort is a system of about 650,000 miles of roads, primary, secondary, and urban, so located as to form the backbone of our 3,000,000 miles of roads in this nation.

The time has now arrived when highway legislation must again be given Congressional consideration. There will be presented to Congress the facts pertaining to the measured need for highways to meet the demands of modern day traffic, the quantitative demands in terms of passenger and commercial vehicles; the trends of use of all types of vehicles which use the highways, including the heavy trucks that have become such an important factor in our national economy and our standard of living. The effect of highway transportation influences our every-day lives in its relation to other forms of transportation and the economy of an adequate highway system that can reduce the cost of transportation of people and goods to a point where it has a definite influence on reducing the cost of production and the standard of living.

All these facts and many, many more will be presented to the law-makers for their consideration in shaping federal highway legislation and putting roads in the proper priority in the federal expenditures.

[1] Reprinted from Road Builders News.

During the twenties we came nearer providing the roads that would meet our traffic demands than any time since. The vehicle count was a little more than one-half of what it is today, but in 1930 we spent approximately $1,500,000,000. After that year, however, our road expenditures dropped to less than a billion dollars though our traffic demands and vehicle count, with few interruptions, rose to over double the number of vehicles that we had in the twenties. Only last year did we equal those early expenditures and then it was with devalued dollars that gave us only one-half as much roads per dollar as we could purchase in 1930.

Thus we have a traffic vehicle demand that is more than double and also is comprised of much heavier loads trying to get along on highway expenditures of one-half of what we spent for roads in 1930.

This lack of construction and reconstruction in our road system has caused a quick increase in the money spent for maintenance. The increase in the number and weights of vehicles, coupled with the heavy traffic demands on an old and often obsolete highway system, means that much of the states' money for highways is going for maintenance, to the extent that generally there is not sufficient left for construction. When this continues it means that too large a percenatge of the states' money is used for maintaining a worn out, obsolete system and not enough used to modernize the system to meet the present day traffic demands.

The nation's maintenance bill now amounts to over $1,125,000,000 and is increasing. This means that more and more of the states' highway money is being spent for maintenance and less and less for construction and reconstruction. If the money is spent more and more for maintenance, it can be seen that the time may arrive when practically all the states' money would go into maintenance, leaving little for the matching of federal aid. This, in turn, means that the necessary construction must be deferred, causing a still greater demand for maintenance.

How this is working in practice is demonstrated by the fact that careful measurements have shown that roads on our 650,000-mile federal-aid system are wearing out at the rate of about 40,000 miles per year. Last year we built about 20,000 miles on this system. So today we are about 20,000 miles worse

off than we were one year ago. And we are maintaining these 20,000 miles of worn out roads at high maintenance cost instead of rebuilding them and maintaining them at reasonable cost.

This uneconomic plan will continue until we have a sufficiently large highway program so we can rebuild our critical roads. This would mean lower maintenance cost. Maintenance money that is saved could then be put into additional highway construction. But first we must get over the "critical" balance and that can only be done by a larger highway construction program.

In 1949 we spent about $1,750,000,000. An economic balance between construction and maintenance could be brought about, and after a few years we could have a highway system that would be efficient and economical in meeting the demands of traffic, if our total highway construction program was about $3,000,000,000 annually. In order to do this and gain the savings that would accrue, we must have a federal-aid authorization of about $1,000,000,000 annually.

To do otherwise we will simply put more and more money into maintenance and the result will be "always maintaining an obsolete system that does not meet demands economically."

Dr. Laurence Ilsey Hewes

DR. Laurence Ilsey Hewes, Chief of the Western Regional Office of the Bureau of Public Roads, Department of Commerce, died suddenly in San Francisco on March 2. He was 74 years old.

In 1911 he was employed by the Bureau of Public Roads, at a time when the science of roadbuilding was in its infancy and the needs for modern highways were first being felt. From the beginning, Dr. Hewes has played an important part in highway development, not only in the discharge of his official duties on assignments of great responsibility, but as an original thinker in the uncharted fields through which highway development has advanced.

Dr. Hewes brought to the highway field an inquiring mind, and a broad education resulting from his studies both within and outside of the field of civil engineering. Always he has been among the leaders in anticipating future needs and in planning to meet them. His own stature has added much to the prestige of Public Roads and of the highway engineering profession generally.

New Federal-Aid Bill Provides $570 Million Annually

THE House Public Works Committee has rewritten and reported out the $570 million per year federal-aid highway bill for 1950. The measure (H.R. 7941) supersedes the originally proposed legislation (H.R. 7398) and contains some important changes.

A new provision in the bill "authorizes and directs" the BPR to assist in carrying out the action program of the President's Highway Safety Conference and to cooperate with the state highway departments and other agencies in this highway safety effort. The sum of $75,000 is authorized for the program.

Provisions of particular interest include the following:

1. $500 million annually, for fiscal 1952 and 1953, is authorized: $225 million for primary, $150 million for secondary and $125 million for urban systems. Apportionment among the states is unchanged from the previous law.
2. An additional $70 million annually is authorized for the Interstate Highway System. Apportionment of funds on this system is based upon population. The language permitting 75-25 matching formula for this system has been rewritten but apparently, leaves the formula unchanged. The traditional 50-50 matching formula still prevails on all other systems.
3. States are permitted to issue bonds for Interstate System construction with the principal to be repaid from future federal-aid funds, but the bill says this shall not be construed as a commitment or obligation on the part of the U.S. to provide such funds.
4. Responsibility for road maintenance of federal-aid roads is placed, in some cases, on cities and counties as well as states.
5. The possible federal share payable for right of way costs is raised from one-third to one-half.

The clause in the old bill which permitted 25 per cent of primary and secondary road funds to be used interchangeably by the states has been removed.

Section nine of H.R. 7398 which provided up to $10,000 a county, from secondary road funds for the hiring of competent county highway engineers, has been eliminated.

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Rock and Gravel Crushing, Screening, Conveying and Washing Plants, Hot and Cold Mix Asphalt Plants, Stabilizer Plants, KU-BIT Impact Breakers, Screens, Elevators, Conveyors, Portable and Stationary Equipment, Hammermills

Jaite Co.
Jaite, Ohio
Multiwall Paper Bags, Sewn and Pasted Style for Packaging Lime, Cement, Plaster, Etc.

Jeffrey Manufacturing Co.
E. First Ave., Columbus 16, Ohio
Material Handling Machinery, Crushers, Pulverizers, Screens, Chains

Joy Manufacturing Co.
333 Oliver Bldg., Pittsburgh 22, Pa.
Drills: Blast-Hole, Wagon, Rock, and Core; Air Compressors: Portable, Stationary, and Semi-Portable; Aftercoolers; Portable Blowers; Carpullers; Hoists; Multi-Purpose and Portable Rock Loaders; Air Motors; Trench Diggers; Belt Conveyors; Drill-Bit Furnaces; "Spaders"; "String-a-Lite" (Safety-Lighting-Cable); Backfill Tampers; Drill Bits: Rock and Core

Kennedy-Van Saun Mfg. and Eng. Corp.
2 Park Ave., New York 16, N. Y.
Material Handling Machinery—Crushers, Pulverizers, Vibrating Screens

Kensington Steel Co.
505 Kensington Ave., Chicago 28, Ill.
Manganese Steel Castings, Dipper Teeth, Crawler Treads, Jaw Plates, Concaves and Hammers

Keystone Driller Co.
Beaver Falls, Pa.
Drills, Power Shovels

King Powder Co., Inc.
Cincinnati, Ohio
Detonite, Dynamites, and Blasting Supplies

Koehring Co.
3026 W. Concordia Ave., Milwaukee 10, Wis.
Excavating, Hauling and Concrete Equipment

Kraft Bag Corp.
630 Fifth Ave., New York 20, N. Y.
Heavy Duty Multiwall Paper Bags

Manufacturers Division—National Crushed Stone Association
(continued)

Lima Shovel and Crane Division
Lima-Hamilton Corp.
Lima, Ohio
Power Shovels, Draglines, and Cranes

Link-Belt Co.
300 West Pershing Road, Chicago 9, Ill.
Complete Stone Preparation Plants; Conveyors, Elevators, Screens, Washing Equipment, Speed-O-Matic Shovels—Cranes—Draglines and Power Transmission Equipment

Ludlow-Saylor Wire Co.
634 S. Newstead Ave., St. Louis 10, Mo.
Woven Wire Screens and Wire Cloth of Super-Loy, Magna-Loy and All Commercial Alloys and Metals

Mack Manufacturing Corp.
350 Fifth Ave., New York 1, N. Y.
On- and Off-Highway Trucks, Tractor Trailers, Six-Wheelers, from 5 to 30 Tons Capacity, both Gasoline- and Diesel-Powered

Marion Power Shovel Co.
617 W. Center St., Marion, Ohio
A Complete Line of Power Shovels, Draglines, and Cranes

McLanahan & Stone Corp.
200 Wall St., Hollidaysburg, Pa.
Complete Pit, Mine, and Quarry Equipment—Crushers, Washers, Screens, Feeders, etc.

Murphy Diesel Co.
5317 W. Burnham St., Milwaukee 14, Wis.
Murphy Diesel Engines Ranging from 90 to 190 Continuous Horsepower at 1200 Rpm. and Packaged Type Generator Sets 60 to 133 Kw. for All Classes of Service

N. P. Nelson Iron Works, Inc.
820 Bloomfield Ave., Clifton, N. J.
Nelson Bucket Loaders

Nordberg Mfg. Co.
3073 S. Chase Ave., Milwaukee 7, Wis.
Cone, Gyratory, Jaw and Impact Crushers; Grinding Mills; Stone Plant and Cement Mill Machinery; Vibrating Screens; Grizzlies; Diesel and Steam Engines; Compressors; Mine Hoists; Track Maintenance Tools

Northern Blower Co.
6409 Barberton Ave., Cleveland 2, Ohio
Dust Collecting Systems, Fans—Exhaust and Blower

Northwest Engineering Co.
135 S. LaSalle St., Chicago 3, Ill.
Shovels, Cranes, Draglines, Pullshovels

Osgood Co.
Marion, Ohio
Power Shovels, Cranes, Draglines, Hoes, Etc., 3/8 to 2 1/2 Cu. Yd.

Pennsylvania Crusher Co.
Liberty Trust Bldg., Philadelphia 7, Pa.
Single Roll Crushers, Impactors, Hammermills, Ring Type Granulators, KUE-KEN Jaw Crushers, KUE-KEN Gyracones

Pettibone Mulliken Corp.
4710 W. Division St., Chicago 51, Ill.
Buckets, Dragline and Parts; Loaders—Car, Bucket; Plants—Asphalt, Portable

Pioneer Engineering Works, Inc.
1515 Central Ave., Minneapolis 13, Minn.
Jaw and Roll Crushers, Vibrating and Revolving Screens, Scrubbers, Belt Conveyors, Traveling Grizzly Feeders

Pit and Quarry Publications
538 South Clark St., Chicago 5, Ill.
Pit and Quarry, Pit and Quarry Handbook, Pit and Quarry Directory, Concrete Manufacturer, Concrete Industries Yearbook

Quaker Rubber Corp.
Tacony and Milnor Sts., Philadelphia 24, Pa.
Conveyor Belts, Hose, and Packings

Rock Bit Sales and Service Co.
350 Depot St., Asheville, N. C.
Tungsten Carbide Detachable Bits, "Rock Bit" Drill Steel Inlaid with Tungsten Carbide, Carbon Hollow Drill Steel, Alloy Hollow Drill Steel

Rock Products
309 West Jackson Blvd., Chicago 6, Ill.

John A. Roebling's Sons Co.
Woven Wire Fabrics Division
Roebling, N. J.
Aggregate Screen, Hardware and Industrial Wire Cloth, Insect Screening, Wire Rope, Fittings and Strand, Slings, Suspension Bridges and Cables, Aerial Wire Rope Systems, Ski Lifts, Electric Wire and Cable, Magnet Wire

Manufacturers Division—National Crushed Stone Association
(concluded)

St. Regis Sales Corp.
1925 Mathieson Bldg., Baltimore 2, Md.
Main Office: 230 Park Ave., New York 17, N. Y.
Automatic Filling and Weighing Machines and Multiwall Paper Shipping Sacks

Sanderson-Cyclone Drill Co.
South Main St., Orrville, Ohio
All Steel Wire Line, Air Speed Spudders, Large Blast Hole Drills, Drilling Tools and Drilling Supplies

Schield Bantam Co.
Waverly, Iowa
Bantam Trench Hoes, Draglines, Clams, Shovels

Screen Equipment Co.
1754 Walden Ave., Buffalo 21, N. Y.
SECO Vibrating Screens

Simplicity Engineering Co.
Durand, Mich.
Simplicity Gyrating Screen, Simplicity D'centegrator, Simplicity D'watering Wheel

Smith Engineering Works
E. Capitol Drive at N. Holton Ave.
Milwaukee 12, Wis.
Gyratory, Gyrasphere, Jaw and Roll Crushers, Vibrating and Rotary Screens, Gravel Washing and Sand Settling Equipment, Elevators and Conveyors, Feeders, Bin Gates, and Portable Crushing and Screening Plants

Stedman's Foundry & Machine Works
Aurora, Ind.
Stedman Impact-Type Selective Reduction Crushers, 2-Stage Swing Hammer Limestone Pulverizers

Stephens-Adamson Mfg. Co.
Aurora, Ill.
Belt Conveyors, Elevators, Feeders, Car Pullers, Screens, Skip Hoists, Complete Plants

Taggart Corp.
(See St. Regis Sales Corp.)

W. O. & M. W. Talcott, Inc.
91 Sabin St., Providence, R. I.
Belt Fasteners, Belt Lacing, Conveyor Belt Fasteners, and Patch Fasteners

Taylor-Wharton Iron & Steel Co.
High Bridge, N. J.
Manganese and Other Special Alloy Steel Castings

Thew Shovel Co.
Lorain, Ohio
Power Shovels, Cranes, Crawler Cranes, Locomotive Cranes, Draglines, Diesel Electric, Gasoline, 3/8 to 2 1/2 Cu. Yd. Capacities

Torrington Co.
Bantam Bearings Division
3702 W. Sample St., South Bend 21, Ind.
Anti-Friction Bearings (All Types and Sizes)

Traylor Engineering & Mfg. Co.
Allentown, Pa.
Stone Crushing, Gravel, Lime, and Cement Machinery

Trojan Powder Co.
17 N. 7th St., Allentown, Pa.
Explosives and Blasting Supplies

W. S. Tyler Co.
3615 Superior Ave., N. E., Cleveland 14, Ohio
Wire Screens, Screening Machinery, Scrubbers, Testing Sieves and Dryers

Universal Engineering Corp.
625 C Ave., N. W., Cedar Rapids, Iowa.
Jaw Crushers, Roll Crushers, Hammermills, Complete Crushing, Screening, and Loading Plants, Either Stationary or Portable for Stone Aggregates or Aglime

Vibration Measurement Engineers
7705 Sheridan Rd., Chicago 26, Ill.
Specialists in Blasting Complaint Investigations; Seismological Surveying; Expert Testimony in Blasting Litigation

Waukesha Motor Co.
E. St. Paul Ave., Waukesha, Wis.
Engines—Diesel, Gas, and Gasoline, Both Independent and as Complete Power Plants, Portable in Smaller Sizes, and Semi-Portable in Largest Sizes, Horsepower Range from 5/8 to over 500 Hp.

Technical Publications
of the
National Crushed Stone Association

STONE BRIEFS

No. 1. How to Proportion Workable Concrete for Any Desired Compressive Strength

No. 2. How to Proportion Concrete for Pavements

No. 3. Uses for Stone Screenings

No. 4. How to Determine the Required Thickness of the Non-Rigid Type of Pavement for Highways and Airport Runways

No. 5. The Insulation Base Course Under Portland Cement Concrete Pavements

ENGINEERING BULLETINS

No. 1. The Bulking of Sand and Its Effect on Concrete

No. 2. Low Cost Improvement of Earth Roads with Crushed Stone

No. 3. The Water-Ratio Specification for Concrete and Its Limitations (Supply Exhausted)

No. 4. "Retreading" Our Highways

No. 5. Reprint of "Comparative Tests of Crushed Stone and Gravel Concrete in New Jersey" with Discussion

No. 6. The Bituminous Macadam Pavement

No. 7. Investigations in the Proportioning of Concrete for Highways

No. 8. The Effect of Transportation Methods and Costs on the Crushed Stone, Sand and Gravel, and Slag Industries (Supply Exhausted)

No. 9. Tests for the Traffic Durability of Bituminous Pavements

No. 10. Stone Sand (Supply Exhausted)

No. 11. A Method of Proportioning Concrete for Strength, Workability, and Durability. (Revised January, 1949)

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Single copies of the above publications are available upon request.

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Manual of Uniform Cost Accounting Principles and Procedure for the Crushed Stone Industry (*$2.00 per copy*)